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ABSTRACT

This report examines issues of politicization in elementary and secondary school science and science teaching. An introductory section introduces the issue of purposeful intrusion of politics into education theories, standards, and curricula. It focuses on the point of entry of politics into science education; the technology of truth; whether or not there is a problem with student performance in science; and national and international science testing. The next section offers a series of case studies of threats to scientific accuracy and integrity in science education, threats that come from both the Left and the Right, focusing on such issues as environmental science and evolution. It explains how these sometimes-obscure developments in curriculum or teacher preparation are likely to influence the quality of science teaching and learning in U.S. schools. The report concludes with a discussion of certain constructivist features shared by people arguing on both sides of these issues, noting the effects on education of making compromises in the curriculum. (Contains 54 notes.) (SM)

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Politicizing Science Education

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by Paul R. Gross

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Politicizing Science Education

by
Paul R. Gross

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Foreword

Of all the maladies of contemporary education, the one that troubles me most is the politicization of the K-12 classroom: the transfer of adult battles into the curriculum and instruction of vulnerable children, and the effort to recruit those children—to *brainwash* them—to take sides in the great policy and political wars of our time.

We ought not be surprised that this happens. Many adults, after all, feel strongly about their various causes. They seek allies and crave recruits. They need to evangelize. They want to win. Where better to find fresh troops for their army than among the young and innocent, those who have not yet formed views of their own, who are too weak to resist the imprecations of the strong, who do not know any better. Besides adding to an army's sheer numbers, children bring with them a veneer of moral rightness. How could one's cause not be noble and just if children believe in it?

Such subversions of the education process take innumerable forms. In some societies, youngsters who know no better and are unable to resist are handed guns, taken out of class, and literally turned into soldiers. In other societies, the opposite happens: they are turned into anti-war protesters. They are brainwashed into joining political parties. They are made to proselytize for, or against, this cause or that movement.

Totalitarian societies are expert at this. They know that shaping the minds of the young by dictating what is taught to them in school (and brought to them via the media and other channels) is a crucial element of political indoctrination and social control.

Free societies are subtler but their schools can be almost as pernicious. Instead of treating formal education as a search for truth, it turns into evangelism for particular points of view, group interests, or ethnic and gender identities. Instead of teaching children to think for themselves, students are purposefully led into certain belief structures of importance to one or another group of adult activists. Instead of being presented with accurate information, they are fed opinions and conclusions.

In recent decades, such things have become so widespread on American *university* campuses that politicization—often derided as "political correctness"—in the curriculum is all but taken for granted. And as nearly always happens, it has seeped into the K-12 curriculum as well. We can easily see it in history and civics textbooks, in literature selections, in geography and economics courses.

Where we might not have expected to find it is in science. The science classroom is, or should be, or we might expect to be, the last bastion of "education as search for truth," the strongest fortress against political

incursions into the curriculum. The very nature of the scientific method, after all, is an ever-skeptical quest for objective evidence that meets standards of rigor and accuracy.

But that fortress turns out not to be impregnable. The tide of politicization is lapping at the walls of science education, too. In places it is seeping under and weakening them.

Our purpose in this paper by Paul R. Gross is to call attention to that seepage and the risks that it poses for education, for science, and for children.

No one is better qualified to examine this large and vexing topic. Paul Gross is himself a distinguished scientist and university professor. Since earning a Ph.D. in zoology from the University of Pennsylvania, he has been professor of biology at five universities, and is now University Professor of Life Sciences *emeritus* at the University of Virginia, where he also served as provost. He has been dean of graduate studies at the University of Rochester and, for a decade, was president of the celebrated Marine Biological Laboratory at Woods Hole, Massachusetts. The winner of many prizes, fellowships, and honorary degrees, and member of many scientific societies, Paul Gross has authored or co-authored innumerable papers, books, and research reports, primarily in biology. Among his recent works is *Higher Superstition: The Academic Left and Its Quarrels With Science* (Johns Hopkins University Press, 1994). Readers wishing to contact him directly may write to him at 123 Perkins St., Jamaica Plain, MA 02130, or send an e-mail to prghome@aol.com.

We invited Dr. Gross to examine the issue of politicization in elementary/secondary school science and science teaching—a sprawling and amorphous topic, to be sure. He has responded brilliantly, by framing the large issues at stake and then offering a series of case studies of threats to scientific accuracy and integrity in science education, threats that come from both left and right. Dr. Gross goes on to explain how these sometimes-obscure developments in curriculum, say, or teacher preparation, are likely to influence the quality of science teaching and learning in U.S. schools.

Who cares? Everyone who is troubled by the weak scientific knowledge and skills with which most young Americans emerge from school should care. Everyone who is alarmed by the performance of U.S. students on international comparisons of science achievement should care. Everyone who believes that our country's future vitality and prosperity depend to no small extent on our scientific leadership and our respect for science itself should care. As Paul Gross clearly explains, to the extent that science classes are consumed by matters other than science, our children will to that extent emerge from those classes without knowing science or respecting truth.

Readers may want to note that the Thomas B. Fordham Foundation will revisit one of the most contentious issues in this field—how states handle evolution in their science standards—in a few months. Stand by for

another important and illuminating paper on the present condition of science education and the incursions of politics into it.

The Thomas B. Fordham Foundation is a private foundation that supports research, publications, and action projects in elementary/secondary education reform at the national level and in the Dayton area. Further information can be obtained from our web site (http://www.edexcellence.net) or by writing us at 1627 K St., NW, Suite 600, Washington, D.C. 20006. (We can also be e-mailed through our web site.) This report is available in full on the Foundation's web site, and hard copies can be obtained by calling 1-888-TBF-7474 (single copies are free). The Foundation is neither connected with nor sponsored by Fordham University.

Chester E. Finn, Jr., President
Thomas B. Fordham Foundation
Washington, D.C.
April 2000

Science is a long history of learning how not to fool ourselves.

—Richard Feynman[1]

A recent exchange of educational opinions has had the 'conservatives' urging that it was necessary to learn factual information, the 'progressives' that it was necessary to encourage thought. But of course, data without thought are worthless, and so is thought without data. To stress the need for even a framework such as the dates of past events is not a mere boring formalism. To think so would be like objecting to a geographer needing a knowledge of latitude and longitude on the grounds that these are no more than tedious distractions from the real seas and continents. On the contrary, they help deploy the world for our minds to grasp. There should be nothing 'left' or 'right' in such a view. It would have been shared by Burke, Mill, and Marx. As a result of ignoring it, a high proportion of the American population is now illiterate or semiliterate, not in any rhetorical sense but by the simplest tests.

—Robert Conquest[2]

Introduction

Purposeful intrusion of politics into education theories, standards, and curricula is common, and science is no longer an exception. This intrusion takes various forms: exaltation of process at the expense of content; trivialization of such content as is covered, eradicating any suggestion of authority on the part of the teacher, which is claimed to inhibit the "construction" of knowledge by the students; and teaching *about* science in social or political generalities, instead of science itself. Such attempts to reshape science classes often have the effect, sometimes the intent, of delegitimizing science as an especially trustworthy form of knowledge. Instead, they promote "other ways of knowing," supposedly equally good ways of knowing, all this when children's ways of knowing their world are being formed. Those "other ways," whatever they are and whatever their theoretical charms, cannot substitute for science.

Before we get to cases-in-point, three preliminaries: First, we need to identify the site within science education of politicizing forces; that is, where in the system politics most often enters, potentially to affect classroom practice and therefore student learning of science. Second, in order to judge the possible consequences of politicization, we need a shared sense of what "science" means, or should mean. Finally, we must be able to agree that there is trouble enough in the *performance* of our students to justify concern about what and how they are being taught, or about what *their teachers* know and are being taught.

Many voices insist that there is nothing to worry about.[3] If, on the other hand, our children do show performance deficits, and if current theories of education for science teachers are weak or superficial in science content, radically critical of it, or irrelevant to it, then that must interact with the other troublesome condition: too few teachers with adequate knowledge of science. Thus politicized theory can contribute significantly to student performance deficits. On tests that examine the substantive content of science, students who have spent science class time learning something other than science will do badly. In which case we should indeed worry about politics in science education.

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Point of Entry

The vast majority of science teachers admire and respect science, and are committed to doing a good job. By evidence of the efforts by these teachers to adapt, adjust, modify, and even replace texts and lessons adopted at higher levels of the system, they are conscientious: ideologues among them appear to be a very small minority. Nevertheless, as I shall argue, parts of the educational research effort in K-12 science (centered in collegiate schools of education), some fashionable pedagogies and approved curricula, and the design and selection of resource materials reflect politically charged theory. The same is true of much motivational literature issued to members by the national science teacher organizations.

Purposeful intrusion of politics into education theories, standards, and curricula is common, and science is no longer an exception.

Such materials reflect the current interests of those who teach science-teaching. Therefore, despite good will toward science on the part of classroom teachers, they must, by their training, by the curricula, resources, and materials provided them, be influenced in what and how they teach. The chief entry points of theory—and politics—into teaching practice are therefore through teacher training, in the literature of science-education research, curricular standards, and resource materials including textbooks. If a claim is widespread in those places, it must influence to some extent what happens in the classroom. How *much* influence these things will have on student performance cannot be estimated exactly: we don't know all the other variables. But the quality of teacher preparation, on the one hand, and politicized injunctions from on high (whether from teacher-training or boards of education), on the other, must interact. Whereas the problems of teacher preparation are getting abundant public scrutiny, however, those of politicized teacher training, and curricula that diminish science in favor of something else, have not.

Technology of Truth

Science is a mutable body of theory and practice for the acquisition of knowledge about the world. Its subject is the workings of nature. It systematizes objective inquiry: the hoped-for result is knowledge that anyone can verify.[4] Such knowledge is useful. Of course, science is not the only kind of systematic inquiry: elements of its practice are present in most other intellectual work. But science has been the world's most comprehensive, consistent, and successful knowledge-acquisition system for nearly 400 years. The words of physicist Richard Feynman (the first epigraph) mean that science helps us—no more and no less—to tell the truth. It does not guarantee truth, or even objectivity; but it is uniquely helpful in striving for both. As philosopher Daniel Dennett puts it,

> We human beings use our communicative skills not just for truth-telling, but also for promise-making, threatening, bargaining, storytelling, entertaining, mystifying, inducing hypnotic trances, and just plain kidding around, but prince of these activities is truth-telling, and for this activity we have invented ever-better tools. Alongside our tools for agriculture, building, warfare, and transportation, we have created a technology of truth: science.[5]

This truth-technology fascinates children. Long before they understand why and how it works, it satisfies curiosity about themselves and their world.

In what follows, I characterize inadequate science education—politicized science education—by way of a few examples of flawed or irrelevant theory—the kind of theory (and practice) taught to future science teachers or pushed into curriculum by non-scientists, or by frankly political intervention. Unfortunately, even an index of all

the categories of politicized curricula would be beyond the scope of this essay. Still, once readers become aware of a few cases-in-point, see their style and content—the typical claims, purposes, and excuses—they may be able to recognize in other categories the sources of science trouble in their own schools.

Student Performance in Science: Is There a Problem?

Is there really a performance problem? You might imagine, given that the content of science is easily recognized, that the answer is a documented "yes," "no," or "yes and no" plus a statement of what, specifically, needs fixing. But we get few such answers. Examples of "no" and "yes" come readily to hand. For example: from a popular magazine normally devoted to well-documented science writing comes a "No; there is no crisis." A national newspaper implies, in an editorial, "Yes; there is a crisis." Each leaves a chasm between assertions and evidence.

Attempts to reshape science classes often have the effect of delegitimizing science as an especially trustworthy form of knowledge.

"No crisis": This is from *Scientific American*.[6] The piece consists of opinions on the supposed crisis from presumptive experts. It provides only opinions; but they are opinions about evidence, more or less as follows (my paraphrases, except for words in quotation marks):

(1) Science education crises are media events, created within the science-education establishment. They generate money for research. There was a big so-called crisis after Sputnik. Another came in 1963 after Admiral Rickover accused American education of failing. Then came one blue-ribbon panel after another, warning that the United States was losing to foreign competitors in the science-technology race. Those warnings were all premature. They were needlessly alarmist. There is no problem.

(2) There has been "no sudden decline in the science and math knowledge of those leaving high school." "Teachers boasted twice as many masters degrees and years of classroom experience in 1996 as those in 1966 did." So things are much the same as they've always been: schools are doing a good job.

(3) It is unfair to compare American students with those in other countries, whose schools may require more science or more time in school. And in some of those high-scoring countries "secondary school seniors are older and much less likely to hold jobs than American kids are."

(4) Yes, tests comparing American students with their foreign counterparts *do* show our high school seniors near the bottom of the heap. But "American teenagers score a bit lower than many peers overseas on a battery of mostly multiple-choice questions emphasizing basic facts and procedures in math and science. So what?"

(5) "The tests don't get at long-term problem-solving skills and concepts about the nature of science."

There is more; but this précis represents the arguments. Most of them defend existing science teaching and curricula, especially the more "progressive"—that is, the vast majority of—curricula. These are claimed to focus on "problem-solving skills and concepts about the nature of science." Such arguments shrug off the test performance of students as unimportant.

A "Yes" answer appeared in *The Wall Street Journal*, whose politics favor privatization, competition, and incentives in K-12 education. The editorial, "Turning Schools Right Side Up," celebrated a recent event.[7] The National Commission

on Governing America's Schools, which "grew out of the well-regarded Education Commission of the States, which is run by all 50 governors," recently issued a long-awaited report. Its thrust is that the nation must try harder to overcome the mediocrity of its public schools. That mediocrity is assumed. It is not, of course, about just science; but it certainly includes science (and mathematics). The *Journal* doesn't think the assumption needs to be defended. The reason given is that, while state education spending has risen heroically (about 70% in real terms) since 1983—the year *A Nation At Risk* was issued—no results of significance have reversed the "rising tide of mediocrity" of which that report so famously spoke.

Science has been the world's most comprehensive, consistent, and successful knowledge-acquisition system for nearly 400 years.

Is the assumption of mediocrity warranted? *A Nation at Risk* was, like succeeding reports, a documented account of serious troubles in K-12 education, including science.[8] It was largely written by distinguished scientists. No convincingly positive changes in the picture of American science education have appeared since it was issued. Evidence of the low scientific literacy of American children abounds; that of our adults is a truism. Comparative test data, the existence and results of which even the "no problem" parties acknowledge, support the charge of mediocrity.[9]

Testing, National and International

Federal and state agencies are the primary data sources. They have for decades monitored school performance and compared the performance of our children with that of children in other countries. Among these sources are the National Assessment of Educational Progress (NAEP) and the International Math and Science Study, of which the third one (TIMSS, 1998) is the most recent.

NAEP achievement levels are "Advanced," "Proficient," "Basic," and "Below Basic." Even "Basic" performance is less than parents should expect. Testing is done at grades four, eight, and 12. In the 1996 series, considering just the grade 12 science results, 3 percent of the students performed at the advanced level. Eighteen percent were proficient. Thirty-six percent reached basic. Forty-three percent fell below that. Is "proficiency" pie-in-the-sky? No. Every reader who knows even a little science and has hopes for children can judge by visiting the sources and getting the facts.[10]

We can also test our kids against their peers in other countries. Here are extracts from the report of Pascal D. Forgione Jr., former U.S. commissioner of education statistics,[11] on the TIMSS.

- U.S. 12th grade students do not do well. When our graduating seniors are compared to the students graduating secondary school in other countries, our students rank near the bottom. This holds true in both science and math, and for both our typical and our top-level students.
- TIMSS is not an assessment of other countries' best students against our average students, but of the entire range of students in each country.
- When we look at the results, we see that the U.S. was among the lowest performing countries on both the mathematics and the science general knowledge assessments.
- U.S. student performance on the assessments in Advanced Mathematics and Physics was among the lowest of participating countries and, in both cases, below the international average.

It is not true that such tests are just too difficult for children. Children in other countries handle them.

The new state standards and tests do not seem, in general, to be excessively or inappropriately "rigorous."[12] Nevertheless, early results confirm the NAEP and TIMSS results. Data from

Massachusetts are typical (the detailed test reports are easily obtained).[13] The 1998 results for science, grade 10 (four, eight, and 10 were tested; children in the lower grades do much better on the whole, as in all such testing): 96 percent of all students statewide were tested. Scoring, *in percentages*, was: Advanced, 1; Proficient, 21; Needs Improvement, 42; Failing, 36. So, the performance of 78 percent of all takers was less than satisfactory. African American students: Advanced, 0; Proficient, 5; Needs Improvement, 30; Failing, 65. For Hispanic/Latino students: Advanced, 0; Proficient, 4; Needs Improvement, 26; Failing, 70. Results of the latest round of testing (1999), just now becoming available, are not very different, although a few schools, after hard work, showed some improvement.

The ills of science education are, finally, a social threat. The best way to close this society's racial divide, which refuses to narrow despite great progress made by minorities since 1950, is to increase the knowledge, social mobility, and economic success of young people who are now—for whatever reasons—at risk. That cannot happen if they remain, on average, poorer performers in science than the already deficient majority.

Politicized Theory: Cases in Point

Attitude Adjustment, not Knowledge

There is no reason why young people cannot learn good science under some favored sociocultural theme, and environmental awareness is one such theme. Teaching science that way is fashionable and theory supports it; "environmental education" is a recognized specialty. Not many working scientists would choose it as the main framework, however; environmental science can be good science, but it is derivative. While it has a conceptual core of its own, the language is basic science and engineering—physics, chemistry, biology (including ecology), hydrology, meteorology, mathematics, and computer science (as in risk analysis). So the difficulties of teaching science *via* environment are considerable. The focus must stay on environment; yet students must acquire quite a lot of hard, basic science in order to understand it.

Still, it can be done. For a high school unit on energy and environment, a certain amount of no-nonsense physics would be necessary. But if there had been decent preparation in the lower grades, one *could* deal with "energy," "heat," and "temperature"; the energetics of radiation, including solar radiation; the lock-up of a minute fraction of that energy on this planet, especially in biomass. Also, of course, with "weather" and climate, local and global. A study of the origins of weather in Earth's angle and rotation could follow. From there, one might take up transformations of energy over time, first by organisms, then by populations, then by whole ecosystems, finally by the human species in its ecosystem. This would be solid science. It would demonstrate the clarity and generality of physics. It would highlight the flow of energy through the biosphere and the global elementary cycles. It could deal with the energy needs and options of humanity; the costs and benefits of alternatives. A hundred other such "umbrella" environmental issues are available.

Too often, however, the science goes begging. Environmental education becomes attitude adjustment. Students learn about such things as primitive paragons of eco-wisdom—indigenous peoples, for example[14]—"living in harmony with nature"[15]; or about the ecological Satans, development and industrialization; or of Earth poisoned in its air, water, and soil. But they do not learn much

of the science needed for actual understanding.

The Independent Commission on Environmental Education (Washington, DC) has studied the whole range of offerings in environmental literacy, and reported on their quality, especially the quality of the underlying science and social science, in curricula, textbooks, teacher guides, and other materials available to students and planners. The members of this commission and its successor (the Environmental Literacy Council) are prominent scientists, engineers, economists, and educators.[16] A report of the commission's studies was issued in 1997, with more recent communications on a range of environmental education topics. The most recent is a detailed study of advanced placement (AP) textbooks in environmental science.[17] The 1997 study endorsed environmental emphasis and education in no uncertain terms; and it judged the quality of science in existing programs, textbooks, and teaching materials. But *that* judgment is in many ways adverse. Among the summary findings:

- "Environmental education should not be confused with environmental science, but materials that are not based on the best available science do not promote environmental literacy."
- "Environmental education materials often do not provide a framework for progressive building of knowledge."
- "Factual errors are common in many environmental education materials and textbooks."
- "Many high school environmental science textbooks have serious flaws. Some provide superficial coverage of science. Others mix science with advocacy."

The report is especially critical of efforts to *substitute* environmental education for the study of science. It makes several recommendations to that effect. Thus:

- "Students in the lower elementary grades should begin the study of science with the study of the natural world."
- "Schools should consider teaching environmental education as an upper-level multidisciplinary capstone course integrating what students have learned in science, social science, and other upper-level courses."[18]
- "Professional scientific and educational organizations such as the AAAS [American Association for the Advancement of Science] and NSTA [National Science Teachers Association] should recommend educational materials only after a detailed, substantive review by experts has found them to be accurate."
- "Environmental education materials at all levels should provide more substantive content in natural science and social science than they now provide."
- "Teachers need substantive preparation in science, economics, and mathematics to teach environmental education."

Environmental science can be good science, but the difficulties of teaching science via environment are considerable.

Any concerned parent, especially of children in the lower grades, can ask at school: to what extent does the environment curriculum emphasize *evidence*? How many of its "activities" focus on science and how many on politics (such as mock environmental hearings—a favorite)? What is primarily to be conveyed: attitude, or knowledge of science?

Environmental science is tough. Its most important ideas come from physical science and economics, not politics and journalism. Teachers with no background in science or economics can show enthusiasm for recommended "activities," and can communicate fears, e.g., about pollution; but many are unable to teach the science. And the "materials" don't necessarily help. It is hard to resist offering an example of "materials" that fail to teach the science but do fulfill social or political purposes. One handsomely produced, 6th-grade guidebook (funded by the Environmental

Protection Agency and the Department of the Interior) is entitled *WOW! The Wonders of Wetlands*.[19] It recommends the performance of rap "music" by groups of students and provides a five-stanza lyric for a start. It begins,

> THE WETLAND wRAP
>
> Yo! I'm Oscar. I'm an otter and I'm really hip.
> I've come to rap with you—I've got a serious tip:
> Ya' know, lately this place seems to be in a mess!
> That's one big problem we should address.
> We've gotta keep the air clean, keep our water clear—
> Do ya' wanna know? Well gimme your ear!
> Wetlands are an answer to some of this trouble,
> So listen to me, and on the double!
> These are lands that are wet—with water, ya' know—
> Those mucky mushy places where awesome plants grow!
> These are homes to fish, birds, mammals (like me!)
> And the really neat thing is they keep the water free
> Of the glop and slop that washes off the land—
> Are you listening friend? Do you understand?
>
> . . .

Not everything in this colorful volume is that silly. It contains some solid material on wetlands and their preservation. But it is highly uncritical as to the underlying science, and naive about law and economics. The result is that what the vast majority of students (and, unfortunately, teachers) will get from it is advocacy—that is, environmental politics—and activities, like "The Wetland wRAP," that pander to early-adolescent tastes and look multicultural, but waste everybody's time and have no useful science-educational purpose.

That most adults cannot judge environmental issues is a grave problem.[20] But teaching environmental crisis makes no sense as a substitute for science. All this might seem to be an argument against environmentalism; but it is nothing of the sort. No sensible person is against environmental awareness, or teaching children, as a core value of civilization, environmental sensitivity. This case—environmental science in politicized form—is merely one example of the most common malady: *substitution of other things, easier things, fun things, and political chic, for science*—then calling them science.

"Reinventing" and "Reconceptualizing" Science

Sandra Harding, a leading feminist philosopher, published *The Science Question in Feminism* in 1986.[21] This early and influential book of feminist epistemology, read nationwide in Women's Studies programs, contains little if anything recognizable as science. The text offers, however, plenty of 1960s-style Marxist slogans, feminist doctrine, indictment of patriarchal evil, and some weird arguments, such as: that Isaac Newton's *Principia* ought to be entitled a "rape manual." This book ends on a triumphant note:

> I doubt that in our wildest dreams we ever imagined we would have to reinvent both science and theorizing itself to make sense of women's social experience.[22]

Reviewing the book in *The American Scholar*, philosopher Margarita Levin wrote, "This megalomania would be disturbing in a Newton or Darwin: in the present context it is merely embarrassing.[23]

Yet: such megalomania is not at all unusual among those who teach teachers to teach science. Here are two simple examples. The first is entirely innocent, albeit pompous, included only for contrast with the second. It is from a handout for teachers enrolling in a 1999 science practicum, *Ways of Knowing in the Physical and Natural Sciences*,[24] at a university in the northeast. The course description announces that

> This course experience will begin the process of the reconceptualization of science. The change will require collaboration,

cooperation, and creativity across domains of expertise.

Nobody since Galileo has really reconceptualized science. The claim that this will be done—even begun—in a college course is pretentious, absurd; but it is innocuous pedagogical cant. Yet not all cant is innocent. Some of it has a conscious political purpose. When that form of cant is fed to future teachers of science, there are potential classroom consequences. For example: a 1998 research paper, in a reputable science-teaching journal, with a title that begins "Reproductive and Resistant Pedagogies."[25]

In this study, the author (M. Mayberry) contrasts "collaborative learning"—a remarkably modish pedagogy, claimed to make learning easier and fairer when students in a class have varied abilities and learning styles—with "feminist pedagogy." Feminist teaching, which is what this paper promotes, calls not only for altered pedagogy but also for radically different subject matter. As the author explains, collaborative learning differs from "traditional" learning. (Traditional learning, we are often told, is elitist.) Yet it troubles the author that collaborative learning, however well-intentioned, selects what is to be learned—the actual course content—from the traditional syllabus. For that, it must be denounced. The methods of collaborative learning simply "reproduce existing forms of knowledge and provide students with skills and tools necessary to join established knowledge communities, *rather than to transform them* [emphasis added]." She does not consider existing forms of scientific knowledge to be the responsibility of curriculum. Rather, the goal of science education should be to transform science.

Feminist teaching calls not only for altered pedagogy but also for radically different subject matter.

This seems to me worse than immodest and more troubling than innocent. Inspired by the writings of Paulo Freire, the Brazilian Marxist and teacher of adult literacy,[26] author Mayberry proceeds to argue that

> The classroom serves as a center of participatory democracy where teachers and students alike engage in this dialogical [sic] experience, the aim of which is to challenge the structures of oppression, repression, and inequality. . . . Through dialogue and conversation, students and teachers negotiate a curriculum that articulates their needs and concerns. These classroom strategies are designed explicitly to empower students to apply their learning to social action and transformation . . . . and become effective voices of change within the broader social world.

So, she argues, even such favored fixes as collaborative learning are inadequate. Plain old science, as she sees it, is irrelevant to the mission of schooling. The job is not to *teach* standard science, but to *reject* it, forging—by classroom conversation strictly among equals—students and the teacher—a new science. This then "empowers" students to transform society. That is, it will train them as revolutionaries.

I can imagine, albeit with difficulty, a few leading scientists conspiring to revolutionize teaching in their fields. But I cannot imagine faculty in Sociology and Women's Studies (Prof. Mayberry is so listed), or even a throng of genuine science teachers, transforming *science itself,* except under delusions of grandeur. Or in the grip of ideology so strong as to anesthetize judgment. Or in political thralldom so deep as to substitute revolution for education. Yet this is not unusual in the literature of science teaching, as a survey of enough of it will show.[27] However much or little ideology of this kind has shown up explicitly, so far, in the nation's K-12 classrooms, it must eventually trickle down.

Resisting "Darwinism," and Keeping the Votes

Consider the durability of anti-Darwinism in

American science education, and its political dimension. This preoccupation is not, I hasten to add, solely of the right. Karl Marx was a fervent admirer of Darwin, but today there is biophobia and anti-Darwinism on the academic left. Acerbic notice has been taken of it in leftist journals of opinion.[28] Nevertheless, anti-Darwinism on the left is insignificant. The right is home to its muscle and treasury. It has been effective in politicizing science curriculum, specifically when there is a hint of disagreement, real or fancied, with religion. Whether from genuine religious feeling or political calculation, elements of the political right wage war against miscalled "Darwinism"—therefore against honest science teaching.

To revile evolutionary science, 140 years after the Darwin-Wallace insight, as "Darwinism" is ignorance or rabble-rousing. It is as silly as would be sneering at NASA's space engineering as "Newtonism."

Why "miscalled"? Because to revile evolutionary science, 140 years after the Darwin-Wallace insight, as "Darwinism" is ignorance or rabble-rousing. It is as silly as would be sneering at NASA's space engineering as "Newtonism" (which in the same trivial sense it is). A few biologists do use "Darwinism" as shorthand for natural selection: the proposal that the spontaneous and heritable variation in all living things, acted upon by varying environments, causes change in population characteristics. A *very* few biologists have mixed biology with deism or atheism, in public; but they are authors of trade books, not curriculum-makers or schoolteachers. Conservative arguments with these writers have nothing to do with the elementary facts of organic evolution. About those, there ceased to be serious question a century ago. Darwin, were he reincarnated, would be bewildered by the enormous scope of evolutionary knowledge today.

In the 19th century, good arguments were raised by naturalists and other thinkers against the proposals of Darwin and Wallace; and well into the 20th century, significant alternatives to Darwin's natural selection were debated and tested. The latter included saltationism, Lamarckianism, and various teleologies. All such arguments were eventually shown to be wrong.[29] The 20th century has ended: so far there have been no new arguments against the facts of evolution, although the old ones, with costume changes, continue to be replayed for the credulous.[30] In the meantime, Darwin's broad principle has become the inextricable core of biology and its applications (like biotechnology and medicine). We cannot comprehend life without understanding it. Our genes are the record, written in nucleotide sequences, of life's history. The broad outline (although not the detail) of the story of life on this planet is scientific knowledge about as solid as the physics of gravity. We don't know everything we want and need to know in either domain—gravity or the history of life; but the solid part of the science is not going to go away. Creationist assertions that "Darwinism is in trouble with the evidence" are propaganda. No *evidentiary* claim against "Darwinism" has so far withstood testing. On the other hand, the evidence in favor of natural selection grows exponentially and meshes ever more tightly with the rest of science.

Evolutionary biologists have squabbles, as do all scientists at the frontiers. But the belligerents are all Darwinians, and *not* because they fear punishment if they demur or defect, as creationists love to hint. Any scientist who found a basic flaw or a genuine, deep gap in evolutionary theory would be an overnight celebrity. It's the kind of thing that happens in science. It happened to Albert Einstein soon after he proposed a significant modification of Newtonian mechanics that made sense to the physics of its time *and* survived subsequent empirical tests. So has the synthesis of Darwinian natural selection, embryology, genetics, and biochemistry made sense—and survived

all tests to date. The claim that evolution by natural selection cannot be "falsified," resurrected from time to time by creationists and amateur philosophers, was an early mistake of philosopher Karl Popper, who later disowned it. Darwin himself, in *The Origin of Species*, suggested possibilities for falsification of his theory. Those tests were all eventually done; so far, no falsification.

Yet anti-Darwinism is tireless. On the broader political right, it gets benign neglect or active encouragement, under the delusion that anti-Darwinism helps religion and hurts liberalism. On the record, it does neither. It is worth noting that a violent attack on the very idea of evolution (what was a few years later to be called "Darwinism") was launched as early as 1850 by Darwin's former geology teacher, and friend, the Anglican minister Adam Sedgwick. He charged that, if evolution is true, "religion is a lie. . . morality is moonshine." But that need not be so; and how sad it would be if the survival of religion depended upon rejection and suppression of science! Ever since the 1925 Scopes trial, whenever it has come up for judicial review, anti-Darwinism has lost. But the troops keep trying, winning victories, mostly small ones, as they have done recently in Kansas and 11 other states. The Kansas spectacle—the most fully developed recent one—is a fine example of politics invading curriculum and trumping truth. More on that below.

Creationist assertions that "Darwinism is in trouble with the evidence" are propaganda. No evidentiary claim against "Darwinism" has so far withstood testing.

Meanwhile: teaching "Darwinism" is not *ipso facto* an attack on religion. There are endless ways in which evolution could have happened in a "created" world—if religion needs a deity-willed Creation. Even if we were to get better answers than we have now to remaining questions about the origin of life on Earth, and they were to prove that it had a material and apparently spontaneous origin, there would still be no necessary conflict. Scores of evolutionists are Christians. Their pleas are that creationism hurts, rather than helps.[11] And of course there is no conflict about elementary facts: the age of the Earth, the provenance of fossils, the unbroken chain that connects humankind to the simplest microorganisms, the details of genetics, embryology, population biology. The evidence so far provides no reason to take species formation ("macro-evolution") as mechanistically distinct from what creationists mean by "micro-evolution"—change within a species. Nor is there anything in the old Argument from Design, refitted and re-floated as Intelligent Design Theory,[12] that wasn't refuted in the 19th century. A dozen rebuttals of the new version (as promoted by biochemist Michael Behe and now a flock of followers) have been published by professional evolutionary biologists, Christians among them. A representative collection of these (that includes Behe's own claims in detail) is on the World Wide Web.[13]

What does all this have to do with politicizing school science? Everything.[14] Biology cannot be taught without the "Darwinism" in evolution. We *could* teach 1840s biology (that is, biology before Darwin). We could satisfy creationist feelings, in fact, simply by pretending that the three major historical sciences—evolution, geology, and cosmology—don't exist. But why should we do that? For whose benefit? Even in the elementary grades, good questions come from children: Why are there so many different animals (and plants)? Are cats and fishes and rats and monkeys "like us"? Can we see a real dinosaur, please? What is the sun made of? Why is it hot? What are stars? We cannot explain stars with 1840s physics. Likewise, science knows no answers to biological relationship questions other than that living things *are* related by descent. As soon as children see and become aware of fossils, learn that they lie beneath our feet, inside rocks, atop Mount Everest—everywhere—they want to know when and how they got there. When they ask, "When will we, please, be taken to see a dinosaur?" we have a choice: the

Flintstones all the way, or the truth. To empty education of what we *know* about these things is to lie to our children.

That's what is done when we delete from the official science standards any reference to *mechanisms* of evolutionary change, and to anything else, in fact, that might offend biblical literalism. Such is the intent of the August 1999 action by the Kansas Board of Education. Supporters of the Board argue that they have not *banned* evolution, but simply deleted from the proposed new state education standards potentially offensive ideas that are "just theories" anyway. Each school and teacher, the Board asserts, will still design local curriculum.

Any scientist who found a basic flaw or a genuine, deep gap in evolutionary theory would be an overnight celebrity.

That is patently disingenuous. What the board did is political correctness, a device for placating a large, politically active (religious, in this case) community. It has nothing to do with what is or is not "just a theory." A full account is available on the World Wide Web, including evidence that the destructive changes to the original standards were authored by a creationist group. These anti-evolution operations in Kansas, Kentucky, Illinois, Oklahoma, etc., are amply covered in local and national media.[15] But the political touchiness of it all is best illustrated by responses of the (currently, as I write) front-running candidates (both parties) for nomination as President of the United States. Questioned about Kansas, both dithered energetically about their respect for local opinion.

In this anti-Darwinist flare-up we have a fine example of the characteristic political double-hex on science: The far reaches of right and left, strangest partners ever in *accouchement*, collaborate. In this, they do little immediate damage to science. But they damage the education of children, hence the future of science. "Well," say some voices on the academic left, "that's democracy."[16] Some conservative intellectuals say much the same.[17] It is a bit of a shock to hear the right and left whistling the same postmodernist tunes: different "ways of knowing"; resistance to the "authoritarianism" or "privileging" of science; the need to honor "alternative" and "marginalized" views of things, for "democracy!" The right, usually slow to learn, has recently learned tricks from the left.

Truth in Quotation Marks: To Each His Own Construct?

The pursuit of truth has been a long-standing, widely shared project of mankind. Now a lot of us seem to have abandoned it. Suspicions that reality is intractable and inexpressible have always been around. As far as we know, they have never been as widespread or as influential or as corrosive of the very concept of truth as they are today.

—Felipe Fernández-Armesto[18]

Constructivism is today the most visible theory of education, including science education. Teachers (and teachers of teachers) proud of keeping up with the research on teaching call themselves constructivists. Philosopher Michael Matthews, more than any other scholar, has drawn together the disparate strands of educational constructivism. In so doing, he demonstrates the ubiquity of the basic doctrines—those shared by most versions. No better evidence of this ubiquity need be sought than the first draft of the long-in-preparation *National Science Education Standards*,[19] issued by a branch of the U.S. National Academy of Sciences. Matthews summarizes the story:

> The 1992 *Draft Standards* recognized that the history, philosophy, and sociology of science ought to contribute to the formation of the science curriculum. But when the contribution of philosophy of science was included in an elaborated Appendix, it turned out to be constructivist philosophy of science. After dismissing a caricature of logical empiricism, the document endorses "[a] more contemporary approach,

often called postmodernism [which] questions the objectivity of observation and the truth of scientific knowledge." It proceeds to state that "science is a mental representation constructed by the individual," and concludes in case there has been any doubt, "The National Science Education Standards are based on the postmodernist view of the nature of science."

. . . . The revised 1994 *Draft* emerged *without* the Appendix, but its constructivist content was not rejected, merely relocated. Learning science was still identified with "constructing personal meaning." And the history of science was seen in terms of the "changing commitments of scientists [which] forge changes commonly referred to as advances in science."[40,41]

It is a bit of a shock to hear the right and left whistling the same postmodernist tunes: different "ways of knowing"; the need to honor "alternative" and "marginalized" views of things.

The quotations embedded here will allow us to extract the most important, shared doctrines of constructivism. In the Draft Standards, this endorsement: "A more contemporary approach, often called postmodernism [which] questions the objectivity of observation and the truth of scientific knowledge"—affirms that educational constructivism is in whole or in part a *postmodernist* view of things; that is, it rejects modernism. Which means that it rejects the enlightenment, the central historical process of modernism, including the scientific revolution that began in the seventeenth century. *Post*modernism does indeed "question the objectivity of observation and the truth of scientific knowledge." Its epistemology denies that objectivity is possible. That denial is claimed to follow from an innocuous, old recognition among philosophers of science that observation is theory-laden (every observation is influenced by the observer's ideas about what is being observed). Postmodernism takes that recognition to the extreme, asserting that no observation can ever test a theory—because observation is itself contaminated by theory. Thus postmodernists and constructivists do indeed "question the truth of scientific knowledge." In fact, to be consistent, they must *deny* it.

Accordingly, most constructivists are relativists (although some disclaim it). For relativists there is no truth, only "truth"—truth in quotes—"a rhetorical pat on the back," as one noted relativist philosopher has explained—a compliment accorded that which is agreed to in some community by that community, but no more than that. Hence there is no robust connection between science and some universal, external reality. To a *social* constructivist,[42] in particular, there can be no "knowledge"; there are only *knowledges*. Not only "Western" science, then, knows the physical world; science is no better a way of knowing it than many other, very different ways of knowing.

That is the force of the statement that "science is a mental representation constructed by the individual." Outside the individual, in other words, there is no independent reality to which "knowledge" or "truth" corresponds. Knowledge of the world is in each human mind, where it is *constructed* from prior and current experience. Some constructivists insist that they are *not* anti-realists—they do not reject reality; only "objectivism" (often misidentified by philosophic amateurs with "positivism"), their label for claims that knowledge can be free of personal and cultural bias. For a serious constructivist, there is no knowledge free of cultural bias. To which, then, the last of these quotations is the appropriate conclusion: that the history of science is no more than "the changing commitments of scientists . . . . [which] forge changes commonly referred to as advances in science." Meaning: there is no real progress toward truth about the physical world. Over the centuries, there have been only changing opinions about it, reached by negotiation and power shifts among contending parties. Scientists just use the term "advances" to label any changes to which

they are finally agreed.

Exploring this bizarre amalgam of postmodernism, epistemological relativism, and old learning theory, the astounded layman may well ask, "How can anyone teach natural science under a theory of science so hostile to its purposes, so blind to its practices and achievements?" The full answer is more than "Well . . . they *don't* teach it," although that is a part of it. But how and why the trick is accomplished, the full story of how one gets away with teaching science under such a rubric, needs a book. Fortunately, several good ones exist.

Science educator and physicist Alan Cromer, for example, has recently examined the methods and results of constructivist teaching, particularly in physics.[43] Cromer is strongly opposed to educational constructivism; thus his book is a convincing, well-documented polemic, but a polemic nevertheless. A more recent, designedly even-handed source is most usefully comprehensive: this is a collection of key papers on constructivist science teaching, pro and con, edited by the indefatigable Michael Matthews. For example, the leading exponent of radical educational constructivism, Ernst von Glasersfeld, offers in this new volume two essays, the first arguing the constructivist position and the second responding to critiques of it by other distinguished authors.[44] Of course there are always abundant current review articles and books of commentary on the primary science teaching literature, as well as books of prescriptive essays, based upon current research, for teachers and student-teachers. And many of the latter are today explicitly and proudly constructivist.[45]

In any event, the literature of science teaching has seen, during the two decades past, a flood of constructivism. Whatever interest these productions may or may not have as philosophy, the scores of papers, reviews, and dedicated journals provide little evidence that constructivist pedagogy has made or will make a difference in student performance. In the United States, in fact, none of the recently proffered pedagogies, constructivist or otherwise, show themselves to date capable of erasing those performance deficits discussed earlier.[46] Still, the question remains: how could so unlikely a philosophy of education have become so prominent in science, K-12? The answer: political appeal.

Two original strands intertwined to make educational constructivism: developmental-educational psychology and an ambitious new sociology of science. The first strand was mainly the work of the Swiss psychologist, Jean Piaget, on childhood acquisition of cognitive skills. Oddly enough, this was strengthened by the work of one of Piaget's rivals, the Soviet psychologist Lev Vygotsky.[47] The latter emphasized, as Piaget had failed to do, the inevitable interdependence of thought and language, and therefore the centrality of teaching—*instruction* (one form of socialization)—in learning. The relevant argument of both accounts, however, is that knowledge cannot be transmitted simply and directly by an (active) knower to a (passive) learner. It must be *constructed* by the actively learning child from what the learner already knows and such relevant events and objects as are in the environment at the time. Moreover, according to the theory, this process changes in character with time as a child's cognitive capacities mature from obligatory concreteness to abstraction. This is the *original* educational constructivism. Although it has been greatly oversold, it is of some use in teacher training, because it emphasizes the importance of knowing what the child already knows and believes, and how that changes in the course of learning. Piaget was, and saw himself as, a scientist and evolutionist. His goal was to produce an account of individual human cognitive development from which the evolution of the species' intelligence might be deduced.

The other strand is the epistemological relativism characteristic of new-style ("post-Mertonian") sociology of science and science-and-technology studies (STS). This is a much more radical view of scientific knowledge and its acquisition. It sees the social (including political) interests of scientists as decisive in the production of science. The seeming contradiction of individual knowledge-construction and "social" is not unremarked: defenders explain that the prior knowledge of the

constructor is itself already socially determined. Constraints, if any, of nature—the way things really are—are far less important, or even absent. Some of the best-known practitioners of STS have argued that "nature" is itself a social construct, or that their goal is to abolish the distinction between science and fiction.[48] Now: mix well the older developmental psychology with the trendier sociology, and you get the constructivist *ragout* now being served up to so many teachers (and *their* teachers).

What are then the components of the stew that make it so tempting, especially in subjects like mathematics and science, to educational theorists and hardworking schoolteachers? The following (please note: *I* don't believe these arguments!):

- Since no "knowledge" can be better than any other, and science is just one way of knowing the world, a way, moreover, that is characteristic of white European males,[49] it is perfectly all right if other kinds of people don't do it well. Science *as we know it* cannot be "multicultural," because some other cultures don't do much or any of *our kind* of science.[50] So we should not expect children who are members of other cultures to do it well.
- Since we are a multi-culture and must therefore teach multiculturally, we should teach science differently from the old, insensitive, "objectivist" way, in which there was overemphasis on memorized, factual knowledge and correct answers. For the constructivist, there are no "correct" answers; only—and there are heavy doubts about this—good and better answers. And what is good or better can be decided only by a knowledgeable "assessor," typically in consultation with the learner, the nature and origin of whose *beliefs* are the real issue.
- The teacher's role is therefore not that of an authority, or a knowledge resource. The effective teacher is a *facilitator* for the learner. This, happily, reduces the teacher's burden of knowing science (or mathematics). What matters, instead, is knowing how to facilitate knowledge-construction (as in "discovery learning") and group dynamics (as in "cooperative learning").
- Since the process of science-knowledge construction is "social through and through" (as one well-known social constructivist insists), and since the social is inherently political, science is *ipso facto* a form of politics. The politics of science, therefore, is at least as important as, or more important than, "rote learning" of scientific terms and concepts, more important than solving set problems with fixed answers.
- Constructivism, postmodern-social-style, is egalitarian, all the way. There is no such thing as scientific or mathematical "talent." Talent is an elitist notion that leads to the evil of tracking. In theory, everybody is good at science because every learning process is the product of each learner's unique, personal history within his or her (relevant) cultural community. One doesn't, after all, call a whole culture or community *wrong* about long division, or simple harmonic motion, or the stages of mitosis in cell-division. Does one? So, for constructivists, objective tests are seriously undesirable. They must be replaced whenever possible by assessments such as portfolio analysis, interviews, and statements of the student's feelings about the subject matter and the learning experience. This gives the "assessor" power, and minimizes second-guessing from the outside.

Educational constructivism is in whole or in part a postmodernist view of things, and postmodernism questions the objectivity of observation and the truth of scientific knowledge.

Conclusion

It should now be evident that our sample cases of politicized science teaching are all members of the same large family. They share certain constructivist features that render politics-in-curriculum acceptable, even honorable.

Consider environmental education once again. What keeps it popular despite the practical difficulties described? Ponder this: if it were indeed more important in science teaching to raise student consciousness of its social and political implications than for them to learn "traditional" science content, then the answer follows clearly. Not only is the environment a major social-political issue arising from science and technology (it being convenient in such arguments to confuse science with technology), but people have very strong feelings about the issues. The political inclination of most of the teaching profession is proudly "pro-environment."[51] Such politics require no deep thought, yet one gets credit for "critical thinking" on matters of grave importance and urgency. The *science* of environment, on the other hand, is hard to understand, even for adults, let alone children. Fortunately, the more radical forms of social constructivism insist that science is whatever we (the community, the class, the gender) agree to call science. Therefore we can teach environmental politics, using science-classroom time for attitude adjustment and, with a clear conscience, call *that* science.

Consider again the case of "liberatory" science (that term is actually used).[52] What makes it possible to imagine soberly that a classroom teacher and a group of school children could "transform" science, in such a way, moreover, as to redeem society? It is possible only if you are honestly convinced that there is no such thing as knowledge, only *knowledges*; that authority is without exception evil; and that nothing not agreed to by every member of a community (a class) can be important. This is naive utopianism, anti-elitism, and egalitarianism—with a vengeance. But it is powerfully encouraged by the epistemic relativism on which the stronger forms of educational constructivism are built. And those who so believe usually get credit for empathy and sensitivity.

Therefore if you know only tendentious accounts of social revolution, and from such accounts have come to believe that revolutions really do start from below; that all trouble in the world comes from above; that people and polities divide cleanly into oppressors and oppressed;[53] then nothing *can* be more urgent, more worthy of being taught to children, than social change. In a constructivist atmosphere, where nobody needs to learn much of "traditional" (or, for feminist-constructivists, "patriarchal") science, there is every reason to substitute something more congenial to social activism and call it "transformed" science. Your pupils will be graded, not by standardized tests, or with numbers and hierarchical symbols (such as A, B, C. . .), but via special "assessments" carried out by yourself or a colleague who sees things as you do. And, nothing of the results of your teaching will matter much in the short term, except the extent to which you adjust children's attitudes.

In short, politics. Best of all: since *you* (or the curriculum designers) decide what science is, you need not worry about those nagging, persistent, best-not-discussed differences in "traditional" science achievement between the majority and some (not all!) minority pupils. If you or a socially well-disposed curriculum maker can decide *ad hoc* what science is, and how the old kind is best "transformed," you can arrange for science to be whatever makes everybody in the class perform. . . . well, definitely above average. Surely, things don't regularly go quite *that* far in most of today's classrooms, but that general direction is certainly the desired one.

"But," you may ask, "what about the ongoing, remarkable creationist renaissance? Those folks are not constructivists, environmentalists, or liber-

ation theologists of science. Most of them are conservatives, political opposites of those others you've been depicting." True enough. But anti-Darwinism, like other forms of rejection of intellectual authority, flourishes best in an atmosphere of delegitimation of science. Such an atmosphere has been created in many corners of the education world. Were there no such atmosphere, creationism would have much less traction. The atmosphere of delegitimation allows *anybody* to deny epistemic distinction to the standard scientific description of the (physical) world. That is what has happened since the 1960s in the contexts of postmodernism, educational constructivism, and their very peculiar versions of educational reform. It could not have happened had there been firm conviction among administrators, school board members, and legislators independently of party, of the general legitimacy of stable (not necessarily of frontier) science. It could not have happened had there been due respect for the long-lived and constantly tested components of evolutionary biology, geology, astrophysics, and cosmology. But once such respect is shaken by constructivism or some other form of epistemological nihilism, well-meaning non-scientists, such as most teachers and school board members, become easy prey to allegations of scientific "privileging." Moreover, in deference to the feelings of various groups and without reference to truth, the federal government itself sets a bad example by its frequent pandering to relativism.

How can anyone teach natural science under a theory of science so hostile to its purposes, so blind to its practices and achievements?

For example, archaeology is stopped because Native Americans lay religious claim to all ancient human remains on their land, even when there is no chance that they are the remains of literal "ancestors." Or a school system stops teaching the science of origins of the earliest humans in this hemisphere because local Native Americans object: *their* origin myth is different. To such objections, the political system now responds routinely: these are indeed different Ways of Knowing, and there should be no "privileging" one way over another.

But how, then, can a school system justify ignoring the passionate objections of religious fundamentalists to the teaching, in science classes, of evolutionary biology? Millions of people subscribe to that Other Way of Knowing, and they feel deeply and sincerely about it. Teaching Darwinism offends their religious and communal convictions; they are certain that they *know* Darwinism to be a conspiracy against religion *and* the God-given rights of parents and families. So, rejecting "creation science" or Intelligent Design Theory as equal-time science, which they are certainly not, can be and has been done; but today it takes a great deal of courage. Educationists, like academics generally, don't have much of that.

As for the larger public, it seems generally content with compromise, with a classic American splitting of the difference: teach both; allow in the name of "balance" Intelligent Design Theory or even biblical literalism to be taught together with evolutionary biology. A recent Yankelovich poll indicates that as much as 79 percent of the U.S. populace—not just religious fundamentalists—are content with allowing literalist creationism to coexist in the curriculum with organic evolution.[54] Almost half of those interviewed hold that the theory of evolution is "far from proven scientifically." Yankelovich himself makes approving sounds, citing the "pluralism" of our society. Thus only a few object when politically pressed school boards agree simply to delete, from the official standards and teaching materials, reference to potentially offensive knowledge from the historical sciences, or demand of publishers (who are not at all loath to comply) that textbooks including such material must have visible disclaimers ("just a theory"), in-text or pasted-on. Thus does *any* compromise with objective knowledge, *every* concession to one or another politically inspired activism, become possible once the notion of natural science as system-

atic inquiry in search of the truth about nature is abandoned. It can then be replaced by something easier and all-around more comfortable. But the replacement is dishonest; and it is bad for the minds of children. However comfortable it may be politically for adults, such compromises and concessions—fiddlings with science under the pretense that knowledge and belief are one and the same thing—surely have much to do with that "rising tide of mediocrity" that threatens to drown us.

Notes

The author acknowledges with thanks assistance in work on which this document is based from the Esther A. and Joseph Klingenstein Fund and from Mr. John Collins and his staff at the Gutman Library, Graduate School of Education, Harvard University.

[1] It was Nobel laureate Feynman who showed us how to stop fooling ourselves about some tough problems in theoretical physics—and about the *Challenger* disaster.

[2] Robert Conquest, *Reflections on a Ravaged Century* (New York: W. W. Norton & Company, 2000), 216.

[3] *Are* there troubles worth worrying about? An excellent general treatment of troubles in science education is in Norman Levitt's *Prometheus Bedeviled: Science and the Contradictions of Contemporary Culture* (New Brunswick, NJ: Rutgers University Press, 1999), although the focus is more on the general culture than on the schools. A commanding treatment of the broad K-12 problem is E.D. Hirsch, Jr., *The Schools We Need and Why We Don't Have Them* (New York: Doubleday, 1996). A view very different from Hirsch's, however, is that of the prolific Howard Gardner, in, e.g., his *Multiple Intelligences: The Theory in Practice* (New York: Basic Books, 1993). For commentary thereupon, however, see James Traub, "Multiple Intelligence Disorder," *The New Republic*, 26 October 1998, 20-23. Sandra Stotsky has published a chilling account of trouble, often of political origin, with the current teaching of reading, the most fundamental of all school skills, in *Losing Our Language* (New York: The Free Press, 1999).

[4] I shall not, in this essay, dwell on the redefinition of science due to philosopher Karl Popper, who held that good scientific theories can never be verified, but that they can be *falsified*. That argument is quite beside the current point; also it is wrong. Readers interested in this old issue might consult, for an amusing exposition of it, David Stove, *The Plato Cult and Other Philosophical Follies* (Oxford: Basil Blackwell, 1991), 1-26. Notice that I limit this discussion to the natural (physical) world. It is certainly possible that there is a *super* natural one. But by definition, *natural* science knows nothing about it. Those who do claim to know it should teach it in other classes, but *not as science*. Knowledge is different from belief. Relativists and postmodernists ignore the distinction; but it is essential for any rational plan of education.

[5] Personal communication; from a presentation by Daniel Dennett at the World Congress of Philosophy, Boston, 13 August 1998.

[6] Gibbs, W. Wayt and Douglas Fox, "The False Crisis in Science Education," *Scientific American*, October 1999.

[7] Editorial, "Turning Schools Right Side Up," *Wall Street Journal*, 16 November 1999, A30.

[8] The National Commission on Excellence in Education, *A Nation at Risk: The Imperative For Educational Reform* (Washington, DC: Author, 1983). "The educational foundations of our society are presently being eroded by a rising tide of mediocrity." (5)

[9] For good documentation on reports from the many commissions and panels, national and state, examining the condition of American schooling, see the early chapters of John E. Chubb and Terry M. Moe, *Politics, Markets, & America's Schools* (Washington, DC: Brookings Institution, 1990). The burden of this book is the need for institutional change; but the early chapters are relevant to the work of all those commissions. Chubb and Moe offer a well-substantiated history of the public recognition of problems in K-12 education.

[10] In the Massachusetts assessment system, the category matching NAEP's "Basic" is called "Needs Improvement." That is much more honest.

[11] Full texts and tabulated data are available on <nces.ed.gov> web pages.

[12] "Rigorous" science is what, according to the "Systemic Reform Initiatives" of the National Science Foundation, all children *"can and must"* learn. See "The National Science Foundation's Systemic Initiatives" and related documents, available at web site <www.ehr.nsf.gov/EHR/ESR/index.htm>.

See also Lawrence S. Lerner, *State Science Standards: An Appraisal of Science Standards in 36 States* (Washington, DC: Thomas B. Fordham Foundation, March 1998).

[13] Massachusetts Department of Education, *Reports of the 1998 Statewide Results, The Massachusetts Comprehensive Assessment System (MCAS)*. The Department's World Wide Web address is <www.doe.mass.edu>.

[14] Environmental education is not alone among subjects in K-12 that are now routinely romanticized for political purposes. Many subjects are thus polished, especially for "heterogeneous" classes, so that texts and other materials may be kept simple. For history, and the treatment of indigenous peoples, there are scores of amusing (but serious) examples. Here is one: the major (and enormous, and expensive!) new history textbook, *United States History: In the Course of Human Events* (from West Publishing, 1997; 1198 pages). A review was done by the articulate and knowledgeable editor of *The Textbook Letter*, William J. Bennetta, who titled it "A Book of Far-Left Propaganda That Fosters Anti-Intellectualism." Consult *The Textbook Letter*, Vol. 7 (6), January-February 1997, 5 et seq.

[15] On indigenous people as paragons of deep ecological wisdom, please see Shepard Krech III, "Playing With Fire," *New Scientist*, 23 October 1999. Also at

<http://www.newscientist.com/ns/19991023/playingwit.html>

[16] A disclosure: Robert L. Sproull, distinguished physicist-administrator and the commission chair, was president of the University of Rochester when I was chairman of biology and then university dean of graduate studies (1971-78).

[17] The original report, from the Independent Commission on Environmental Education, was entitled *Are We Building Environmental Literacy?* (Washington: ICEE, 1730 K Street NW, Suite 905, Washington, DC 20006, 1997; ISBN: 1-878831-05-4). Successor to the original commission is the Environmental Literacy Council, at the same address. The Advanced Placement environmental science textbook review and other useful materials on teaching sound environmentalism can be accessed via the Council's web site, <www.enviroliteracy.org>, and from the Council directly. General information from <info@enviroliteracy.org>.

[18] The College Board offered an Advanced Placement (AP) Environmental Science exam for the first time in 1997.

[19] Allen S. Kesselheim, et al., *WOW! The Wonders of Wetlands: An Educator's Guide* (St. Michaels, MD: The Watercourse, 1995).

[20] The list of environmental crises that are not crises, and crises that are not environmental, is long. It is growing, as "green" politics become ever important (in Europe, essential) for winning elections. The literature on such crises is vast, written from many points of view, technical and political. Its arguments are given pride of place in all the mass media. But a good lay-person's study list should include not only the environmental advocacy and self-promotion of the dozens of organizations, governmental and private, devoted to it, but also books from individual, serious environmentalist authors who reject the fashionable greenery and the TV scares. Some examples: Michael Fumento, *Science Under Siege: Balancing Technology and the Environment* (New York: William Morrow, 1993); Martin W. Lewis, *Green Delusions: An Environmentalist Critique of Radical Environmentalism* (Durham, NC: Duke University Press, 1992); S. Robert Lichter and Stanley Rothman, *Environmental Cancer—A Political Disease?* (New Haven: Yale University Press, 1999); Peter Huber, *Hard Green: Saving the Environment From the Environmentalists* (New York: Basic Books, 1999).

[21] Sandra Harding, *The Science Question in Feminism* (Ithaca, NY: Cornell University Press, 1986).

[22] This and other quotations from Harding's *The Science Question* are discussed in detail in Paul R. Gross and Norman Levitt, *Higher Superstition: The Academic Left and Its Quarrels With Science* (Baltimore, MD: Johns Hopkins University Press, 1998), chapter 5.

[23] Margarita Levin, "Caring New World," *American Scholar* 57 (Winter 1988), 100-106.

[24] The handout is for a course that was offered in Fall 1999 at Clark University, in Worcester, Massachusetts. Anyone wishing to pursue the matter will doubtless find records in the university's education program catalogues. The course was probably a good one; but surely it did not "reconceptualize" science.

[25] Maralee Mayberry, "Reproductive and Resistant Pedagogies: The Comparative Roles of Collaborative Learning and Feminist Pedagogy in Science Education," *Journal of Research in Science Education* 35 (1998): 443-459.

[26] See Paulo Freire, *Pedagogy of the Oppressed* (New York: Continuum, revised 20th Anniversary Edition, 1999). Half a million copies of this little book have been sold, worldwide. As Ivan Illich says in his front-cover blurb: "This is truly revolutionary pedagogy."

[27] For more detailed comment on the current research literature in science pedagogy, see Paul R. Gross and Sandra Stotsky, "How Children Learn Science: Do We Now Know?" and other essays in Sandra Stotsky, ed., *What's at Stake in the K-12 Standards Wars?* (New York: Peter Lang, 2000, in press).

[28] Barbara Ehrenreich and Janet McIntosh, "The New Creationism: Biology Under Attack," *The Nation*, 9 July 1997. "Biophobia" is a word for the common suspicion and dislike of biology among social scientists, literary persons, and the politically savvy. Any biology that bears, potentially, upon human behavior makes people very uneasy.

[29] For a recent, authoritative, and highly readable account, see Ernst Mayr, *This is Biology: The Science of the Living World* (Cambridge, MA: Belknap Press, 1997), chapter 9.

[30] A fascinating, encyclopedia-like compendium of the arguments against evolution and "Darwinism," over the entire range from interesting to stupid, is: Tom McIver, *Anti-Evolution: A Reader's Guide to Writings Before and After Darwin* (Baltimore: Johns Hopkins University Press, 1992). Readers who care to study sys-

tematic, university-level presentations of the serious arguments for and against "Darwinism" and their resolution must read a real textbook, not popular science or the quasi-philosophical posturing of ID "theorists." Recommended: Mark Ridley, *Evolution, 2nd edition* (Cambridge, MA: Blackwell Science, 1996).

[31] See, for a good, typical example, the impassioned essay by biologist Kenneth L. Miller, "Finding Darwin's God," Brown [University] *Alumni Magazine* 100, no. 2 (November-December 1999): 37-43. The succeeding issue devotes several pages to letters of response.

[32] An authoritative collection of scholarly articles intended to promote Intelligent Design (ID) as a legitimate *scientific* alternative to Darwinism: volume 1, no. 4 of *Rhetoric and Public Affairs* (Winter 1998). The entire issue is given over to (mostly special) pleadings on the matter. The current version of ID is sponsored by, and beloved of, evangelical Christians and some (but by no means all) biblical literalists. Many of the latter—and the American public at large—seem to be unaware that ID is inimical to literalist ("young Earth") creationist ideas, since the current fall-back position of ID (e.g., Michael Behe's) is that a Designer started it all (life on Earth), but does not perceptibly intervene in the actual processes of evolution. Intellectual evangelicals, on the other hand, seem not to care about this difficulty: they want only to show that the evidence for "Darwinism" is flawed, and that non-materialist alternatives to "Darwinism" are therefore possible. Unfortunately for them, ID is not an alternative to any kind of science. It is a logical fallacy: call it the argument from incredulity.

[33] Web page: *Behe's Empty Box*, J. Catalano, operator, on <spacelab.net>.

[34] See Paul R. Gross, "Downsizing Darwin," *The Boston Globe*, 17 May 1998. Also: *The Wichita* (Kansas) *Eagle* reports on 6 January 2000 that the governor, despite his public disapproval of the action of the Board of Education in removing from the K-12 science standards all reference to evolutionary origins (and cosmology), will not do anything about it even though he has the power to intervene. He is reluctant, the piece reports, to become involved in "Board of Education politics."

[35] For the Kansas story, in detail, see <http://www.kcfs.org/announce/>. For the broader picture, see Editorial, "Combating the Exploiters of Creationism," *Nature* 402 (1999): 843.

[36] Norman Levitt, *op. cit.*, provides Chapter 13, "Democracy," for discussion of perversions of this word as used by some influential academics and among the intelligentsia.

[37] I refer here to the public yearnings of some distinguished neo-conservative thinkers who are otherwise trenchant commentators on contemporary culture. They wish for a social order and political life disciplined by sincere, universally held religious beliefs. These are beliefs, however, that they surely cannot themselves—on the evidence of their other positions and arguments—hold with any rigor.

[38] Felipe Fernández-Armesto, *Truth: A Guide for the Perplexed* (New York: St. Martin's Press, 1999).

[39] The current, publicly sold version of the *National Science Education Standards* can be accessed at, or purchased from, <http://www.nap.edu/readingroom/books/nses>. Most college and university libraries have copies.

[40] Michael R. Matthews, "Constructivism in Science and Mathematics Education" in D. C. Phillips, ed., *NSSE 100th Yearbook* (Chicago, IL: University of Chicago Press, in press). NSSE is the National Society for the Study of Education, founded by John Dewey just a century ago.

[41] Matthews has made use here of an account by the distinguished historian of science, Gerald Holton: "Science Education and the Sense of Self," in Paul R. Gross, Norman Levitt, and Martin W. Lewis (eds.), *The Flight From Science and Reason. Annals of the New York Academy of Sciences* 775 (1996): 551-60. Also from The Johns Hopkins University Press, 1997.

[42] The relevant tenet of *social* constructivism is that knowledge is a social phenomenon, from which it follows that knowledge, and even "reality," are *created* by social (or cultural) circumstances. If so, then truth as well must be a social phenomenon. It can therefore never be universal, there being thousands of different societies (or cultures).

[43] Alan Cromer, *Connected Knowledge: Science, Philosophy, and Education* (New York: Oxford University Press, 1997).

[44] Michael R. Matthews, *Constructivism in Science Education: A Philosophical Examination* (Dordrecht: Kluwer Academic Publishers, 1998).

[45] A recent and particularly authoritative example (because of the prominence of some of the authors in science-education research) is Jack Rhoton and Patricia Bowers, eds., *Issues in Science Education* (Arlington, VA: National Science Teachers Association, 1996).

[46] Gross and Stotsky, *op. cit.*, provide an historical account of the Piagetian origins of constructivism and related science pedagogies, survey the literature, and argue that it provides no empirical support for claims that such pedagogies make much difference, on any meaningful scale, in science learning by children in the United States. The failure of constructivist (and other fashionable) pedagogy to improve student achievement in science is not, however, an argument advanced solely by critics of constructivism. It is admitted freely by most radical "reformers," who nevertheless consider educational constructivism very good theory indeed. They have excuses for its failure to work. Here, for example, in a keynote address he gave to the last (1999) Annual Meeting of the Association for the Education of Teachers in Science (Austin, TX), is the oblique admission of educational researcher Alberto J. Rodriguez, of the Department of Curriculum and Instruction, New Mexico State University:

> [I]n the last 25 years of research in science education, we have accumulated a great deal of knowledge about teaching and learning. This knowledge has primarily served us as a research community, but it has had little impact on how teachers teach, on how students learn, and on the existing social inequalities that continue to make teachers' work so impossible.

One wonders how the new knowledge of teaching and learning can have "served" the research community without having had any impact upon teaching and learning. The excuse is there, however: the "existing social inequalities."

[47] Contributions of Piaget and Vygotsky are discussed in this context by Gross and Stotsky, *op. cit.*

[48] This specific claim is due to the sociologist of science, Bruno Latour. It is cited, discussed, and given context in Gerald Holton, *Science and Anti-Science* (Cambridge, MA: Harvard University Press, 1993), 151-56.

[49] Certainly not *dead* white European male *scientists*. Most of the scientists who have ever lived are alive and at work today. This is one consequence of the exponential growth of science and technology.

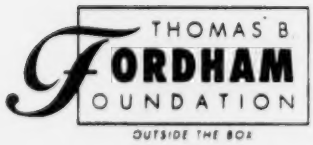
[50] This is of course not true; it hasn't been for a hundred years. Right now there might well be more scientists per square foot of Tokyo, or Taipei, than of New York.

[51] "Pro-environment," when used as it normally is for such self-congratulation, implies—absurdly—that some other person or group is *anti*-environment. So far, however, no party or group has been identified whose members really are opposed to the environment and committed to destroying it.

[52] See, for an example and context, the announcement, in one of the foremost journals of science teaching, of a special issue to be concerned with "marginalized discourses (i.e., progressive, critical, feminist, and poststructural theories) and our understanding of liberatory and democratic science education for all." This is in Levitt, *Prometheus Bedeviled, op. cit.*, 174-76).

[1]Or, as Colonel Cathcart, of Joseph Heller's *Catch-22*, formalizes the entire world of events: they are either "a feather in my cap" or "a black eye." Alternatively, in that favorite slogan of the cognitively challenged: "If you're not a part of the solution, you're a part of the problem."

[2]"Evolution and Creationism in Public Education: An In-depth Reading of Public Opinion." Prepared by DYG, Inc., for the People for the American Way Foundation, March, 2000. See report on the web site of People for the American Way: <www.pfaw.org>.



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